

Modeling Capabilities during SEAC⁴RS-NA: *Forecasting Support and in-Field Data Analysis*

Arlindo da Silva⁽¹⁾ , Louisa Emmons⁽²⁾ , Pablo Saide⁽³⁾

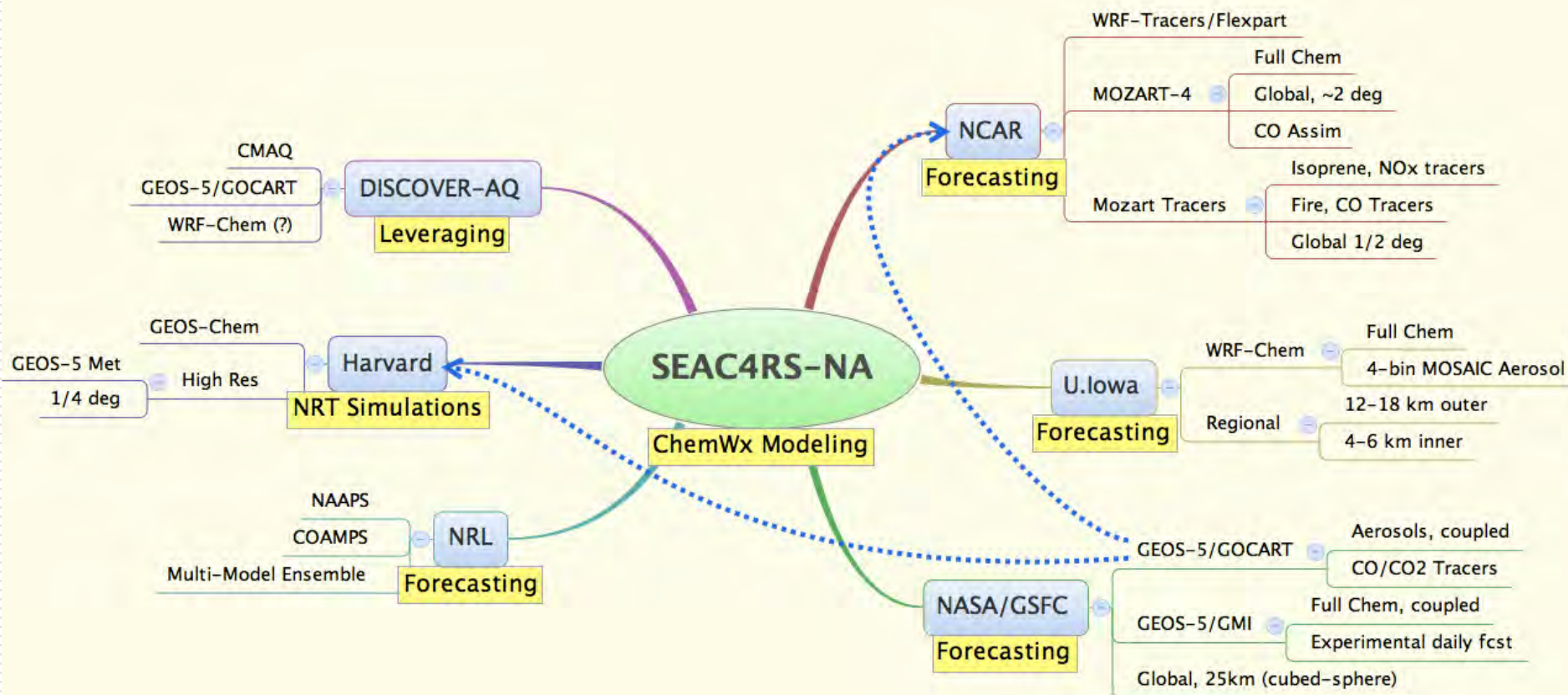
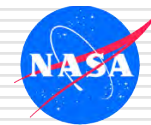
(1) Global Modeling and Assimilation Office, NASA/GSFC

(2) NCAR

(3) University of Iowa

*SEAC4RS Science Team Meeting
April 29-May 1 2013*

SEAC4RS-NA Modeling Capabilities at a Glance



NCAR Modeling Support for SEAC4RS

Louisa Emmons

Mary Barth, Gabriele Pfister, Helen Worden,
Mijeong Park, Christoph Knote, Christine Wiedinmyer

Atmospheric Chemistry Division, NCAR

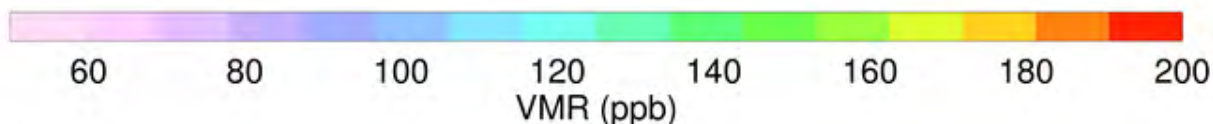
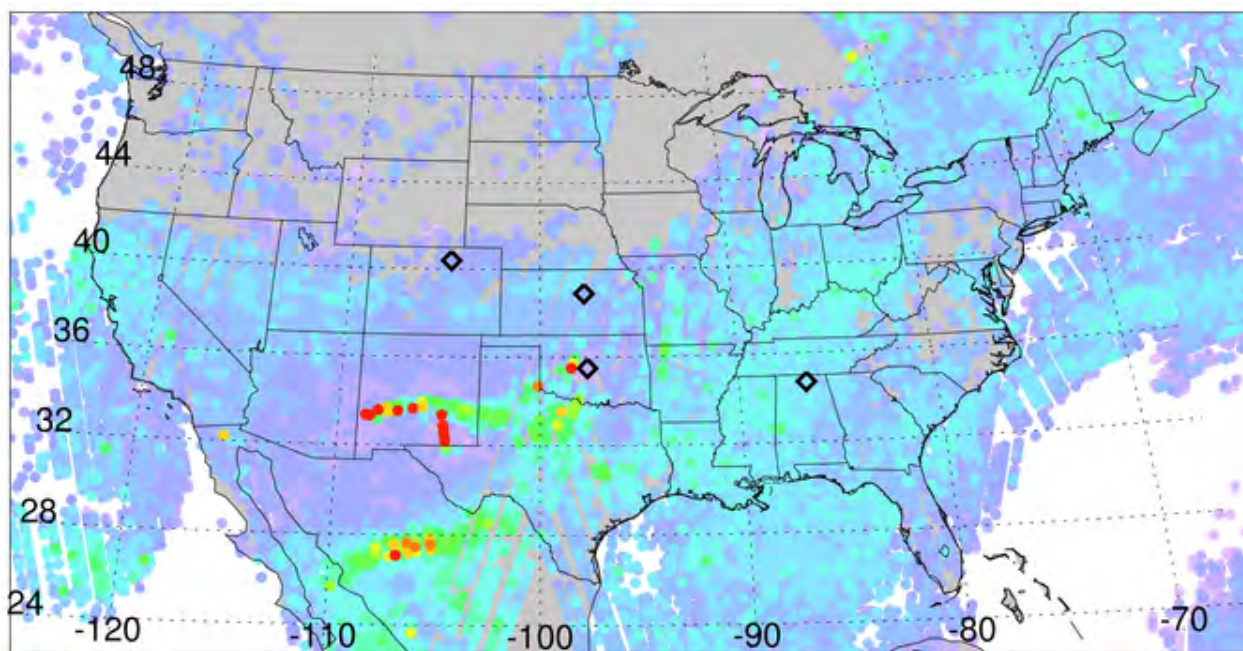
Carbon Monoxide Satellite Observations

- MOPITT CO – available within a day of overpass
- IASI CO – about 2-day delay, global coverage 2x/day
- Plots will be available at: <http://www.acd.ucar.edu/acresp/>

NCAR/FORLI

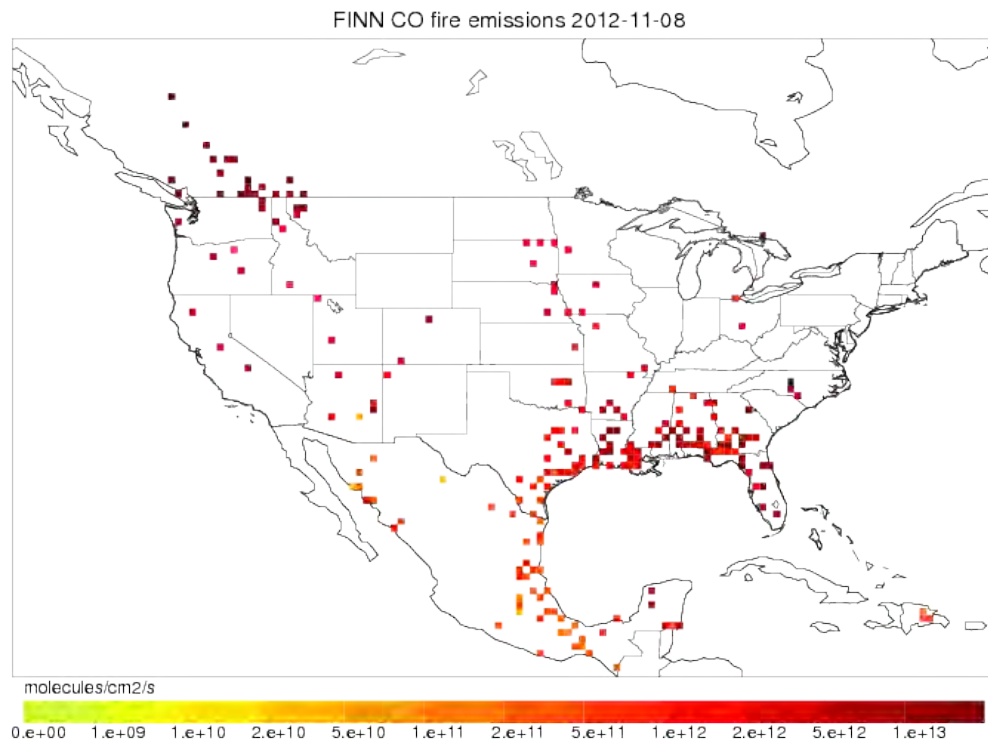
IASI CO Total Column Effective VMR

24 May 2012

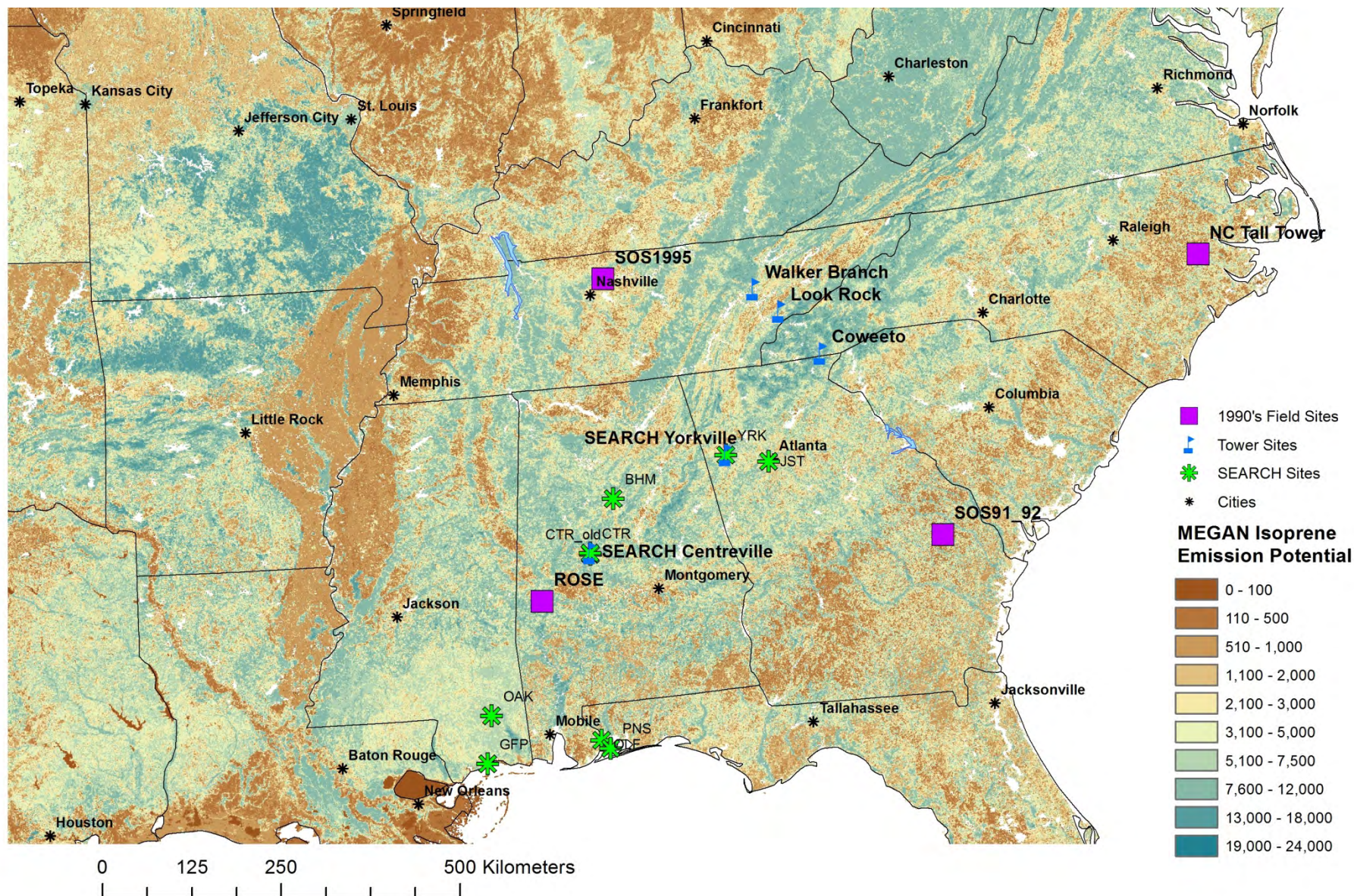


Fire Emissions: Fire INventory from NCAR (FINN)

- Daily fire emissions of trace gases and particles are produced
- FINN is run in real-time based on MODIS Rapid Response fire counts [*Wiedinmyer, GMD, 2011*]
<http://www.acd.ucar.edu/acresp/forecast/fire-emissions.shtml>
- Plots and data files available each day



MEGAN: biogenic emissions model –
online in MOZART, CAM-chem/CLM, WRF-chem
real-time emissions can be made available



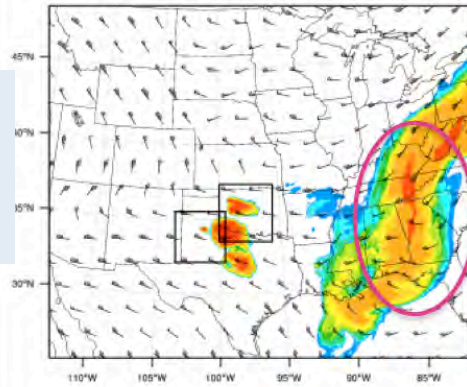
WRF-Tracers and Flexpart – Example from DC3

for SEAC4RS, simulations will be chosen to address science questions

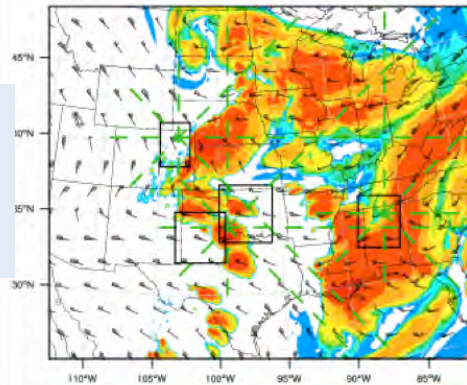
WRF ($\Delta x=3\text{km}$)
with PBL tracers

2012-05-31_00:00:00

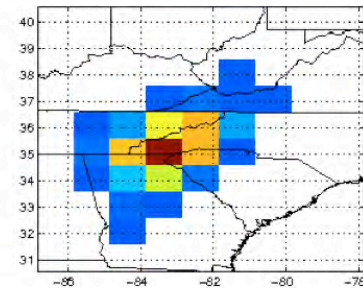
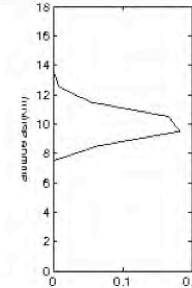
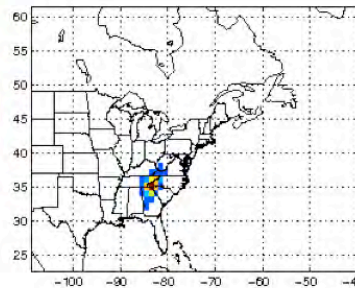
8-16 column Oklahoma Tracer (%)
Wind (kts) at 11 km



8-16 column BL Tracer (%)
Wind (kts) at 11 km



Tracers & Flexpart Trajectory Forecast



Tracer forecast from Flexpart initialized at ~01 UTC 05-30 at the latitudes, longitudes, and altitudes of the GV anvil passes. Results are valid for 18 UTC 05-30.

Tracer forecast from NCAR WRF initialized at 12UTC 05-29

PBL tracer from
Oklahoma/West
Texas at 11 km

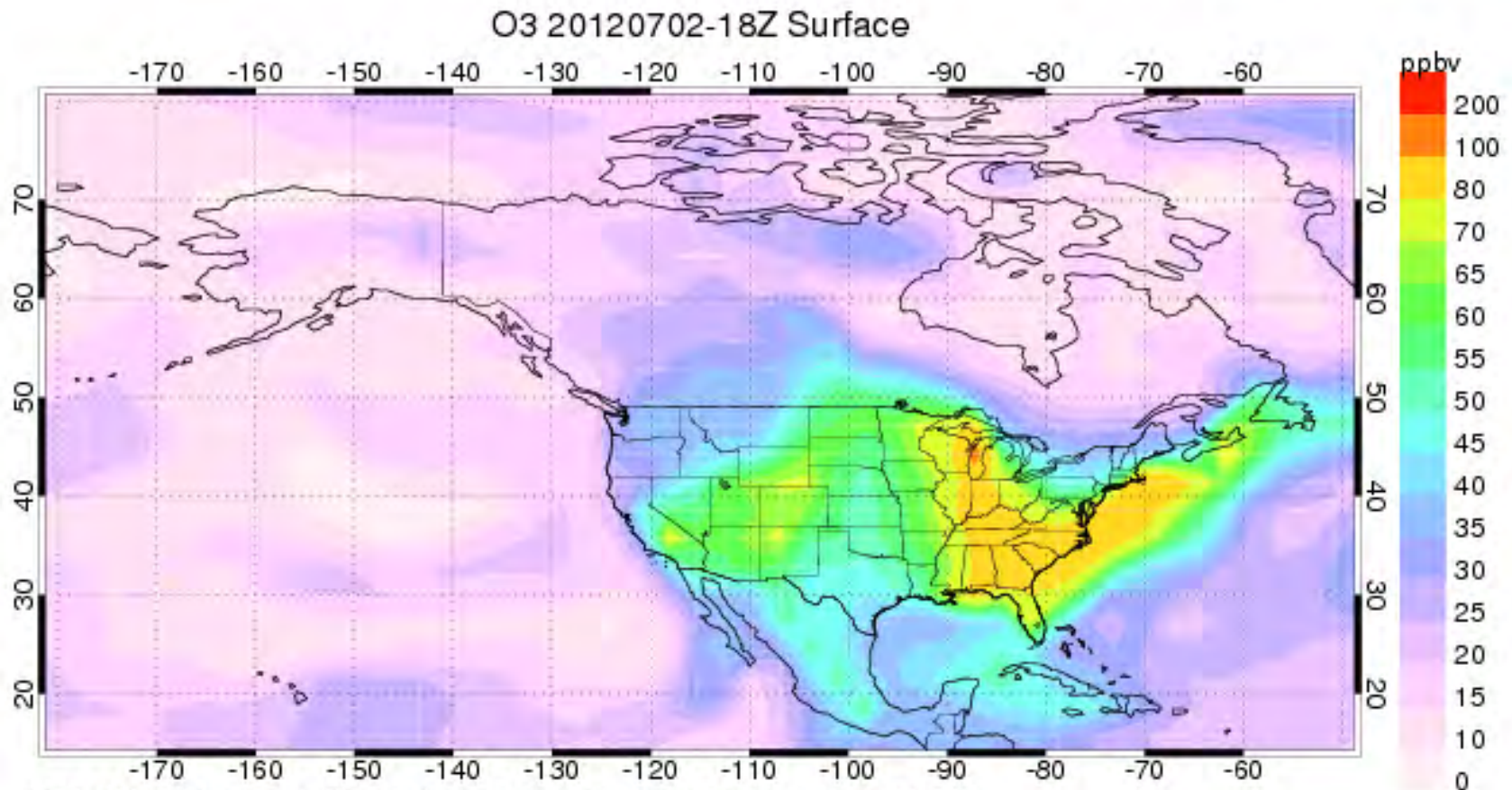
PBL tracer from
entire domain
in UT

MOZART-4 driven by GEOS-5 with assimilation of MOPITT CO

Full chemistry at $1.9^\circ \times 2.5^\circ$

<http://www.acd.ucar.edu/acresp/forecast/>

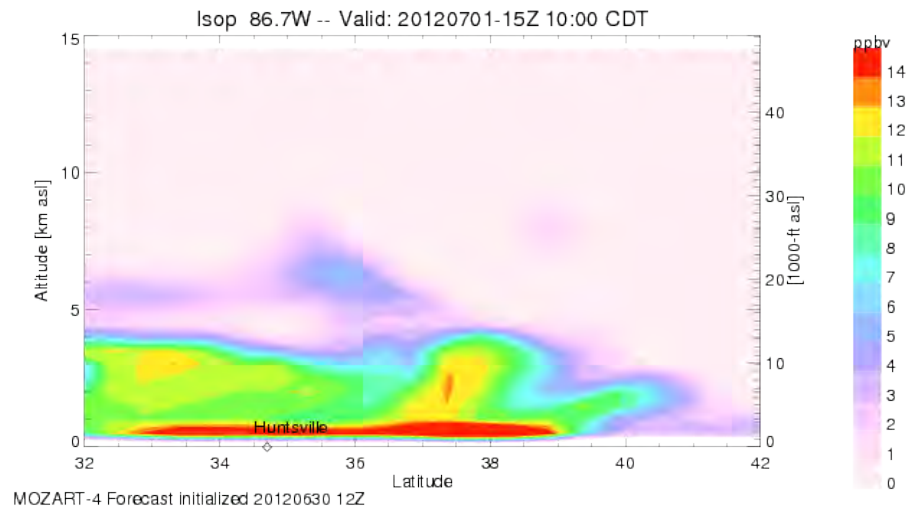
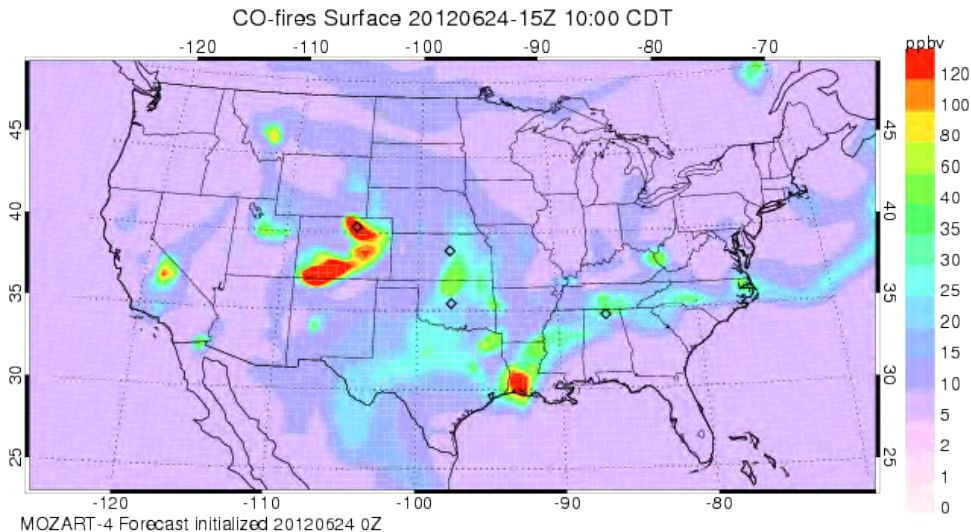
5-day forecasts, hourly output, currently operational



MOZART-4 Tracers

Global forecasts of artificial tracers at $0.5^\circ \times 0.6^\circ$

- Isoprene-like tracer based on MEGAN isoprene emissions
- Anthropogenic NO_x tracer
- Fire & anthro CO tracers for various regions
- Others can be added as needed
(based on various sources, lifetimes, soluble/insoluble)
- Similar to forecasts for DC3 (<http://www.acd.ucar.edu/acresp/dc3/>)



Post-Campaign Analysis

CAM-chem and WRF-chem will be run after the campaign and provided to the Science Team for analysis of the observations

- FINN fire emissions will be updated with final MODIS thermal anomalies and regional burn information and used in the model simulations
- CAM-chem (MOZART-4 chemistry) will be driven by GEOS-5 (or MERRA) meteorology
- WRF-chem will be run with MOZART-4 chemistry and aerosols (MAM & SOA)
- Model results will be interpolated to the flight tracks and submitted to the data archive
- Science Team may request other (custom) products

UIOWA Forecasting Capabilities

Pablo Saide, Greg Carmichael, Scott
Spak

SEAC4RS science meeting

April 29th, 2013

UIOWA Forecasting Capabilities

- WRF-Chem full chemistry+4 bin MOSAIC aerosol and WRF-tracer for emission regions/sectors
 - 12 or 18km resolution, with a inner moving nest of 4 or 6km
 - 3 day forecasts, NAM or GFS meteorology
 - MOZART or MACC (ECMWF) chemical boundary conditions
 - FINN or QFED fire emissions, MEGAN biogenics, GOCART dust
 - NEI or D. Streets SEAC4RS anthropogenic emissions
 - Radiative feedback on, aerosol activation off (but aerosol number concentration used as proxy)
- AOD assimilation using NASA NNR or NRL-UND products
- Post processing through NCL and/or UPP
- Output on UIOWA webpage and possibly on NASA through OpenDap server
- All flexible depending on this meeting decisions

[BACK GO TO CROSS-SECTION](#)

**SEAC4RS 18km Full
Chemistry and Tracer
Forecast, 00h = 06UTC,
26/06/2012**

Please select pressure ,
START and END time step
 to see

Full Chemistry:

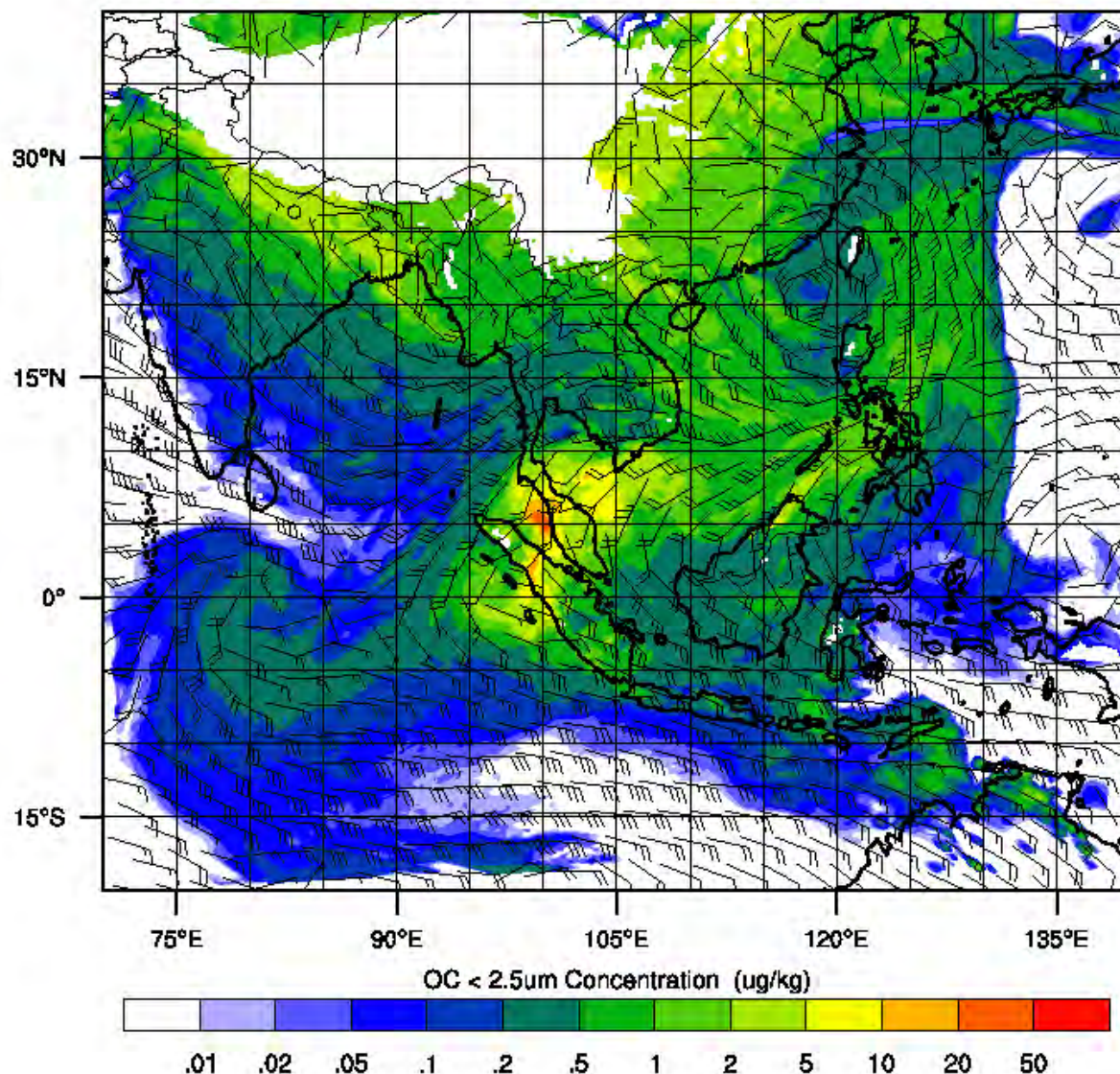
Tracers:

Meteorology:

UIOWA WEBPAGE

Init: 2012-06-26 06:00:00
Valid: 2012-06-29 06:00:00

OC < 2.5um Concentration (ug/kg) at 850 hPa
Wind (kts) at 850 hPa



UIOWA WEBPAGE

[BACK GO TO MAPS](#)

**SEAC4RS 18km Full
Chemistry and Tracer
Forecast, 00h = 06UTC,
26/06/2012**

Please select Cross-section # ,
START and END time step
 to see

Full Chemistry:

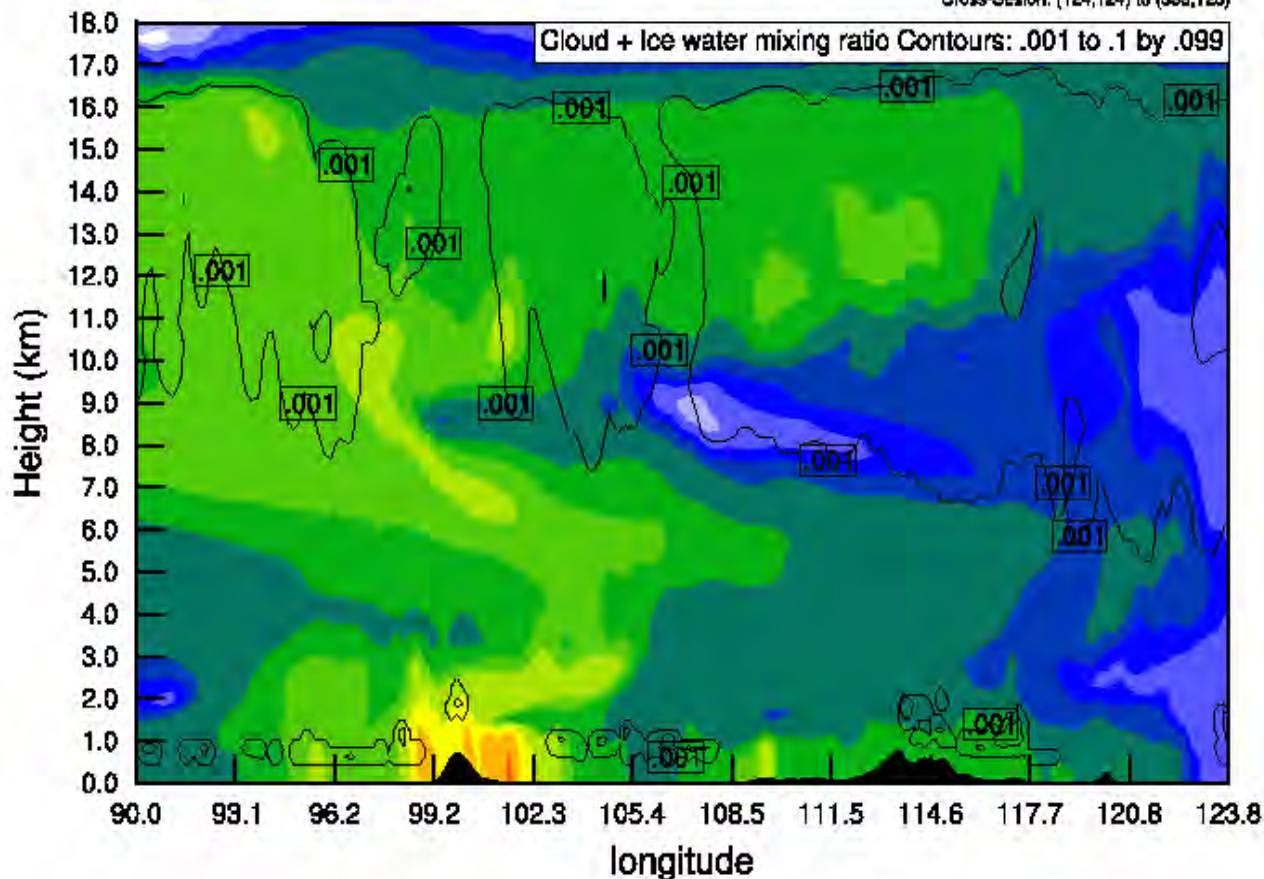
Tracers:

Ind.Oc., Sumatra, Singapore, Borneo, (90E,0N) to (124E,0N)

Init: 2012-06-26_06:00:00
Valid: 2012-06-29_06:00:00

OC < 2.5um Concentration (ug/kg)
Cloud + ice water mixing ratio (g/kg)
Main

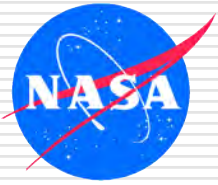
Cross-Section: (124,124) to (393,125)



OC < 2.5um Concentration (ug/kg)



.01 .02 .05 .1 .2 .5 1 2 5 10 20 50



GEOS-5 Forecasting Support for SEAC⁴RS-NA

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⁽¹⁾ *Global Modeling and Assimilation Office, NASA/GSFC*

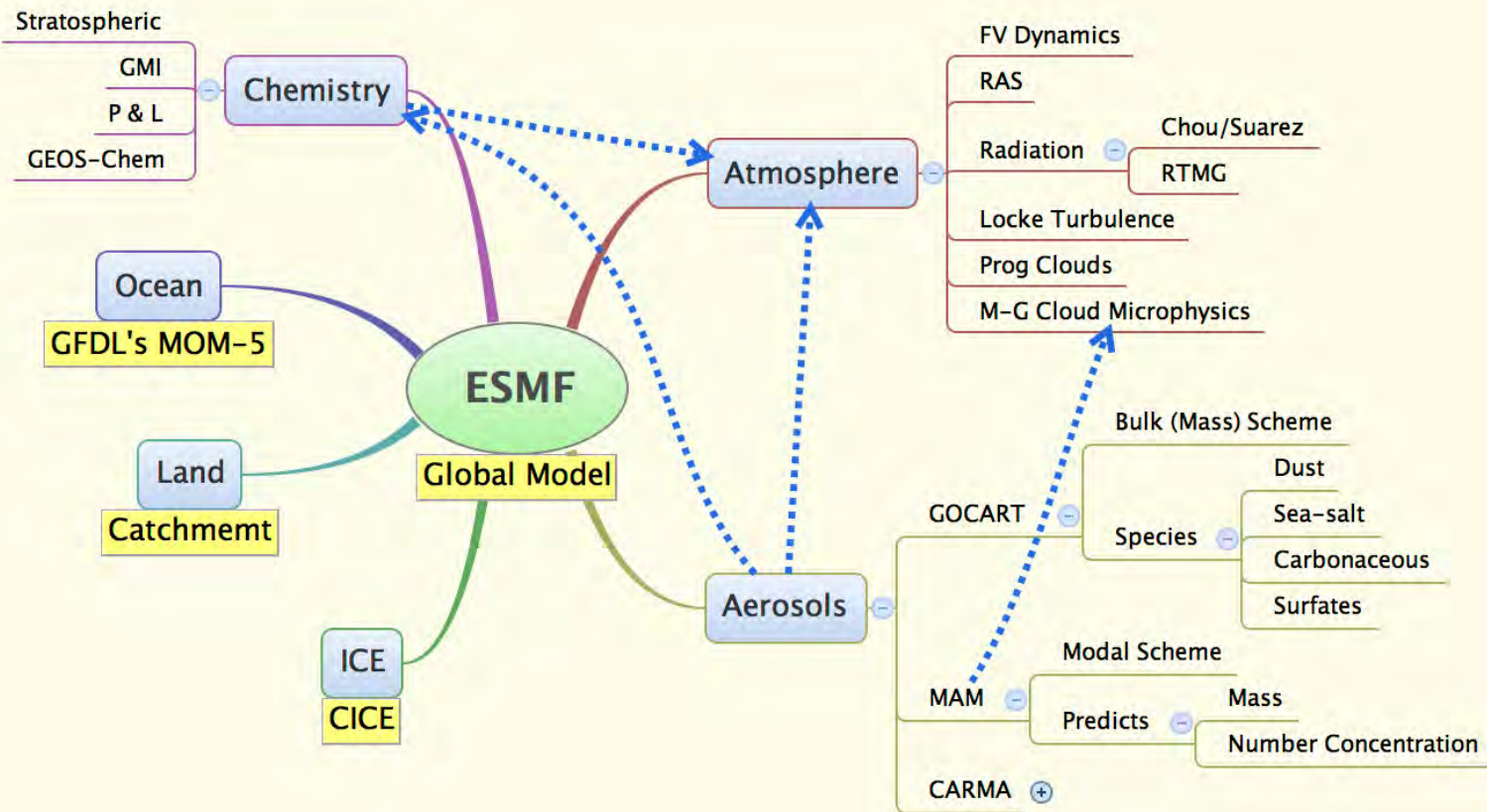
⁽²⁾ *Atmospheric Chemistry and Dynamics Branch, NASA/GSFC*

⁽³⁾ *Morgan State University/GESTAR*

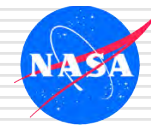
⁽⁴⁾ *ORAU*

⁽⁵⁾ *SSAI*

GEOS-5 Earth-System Model



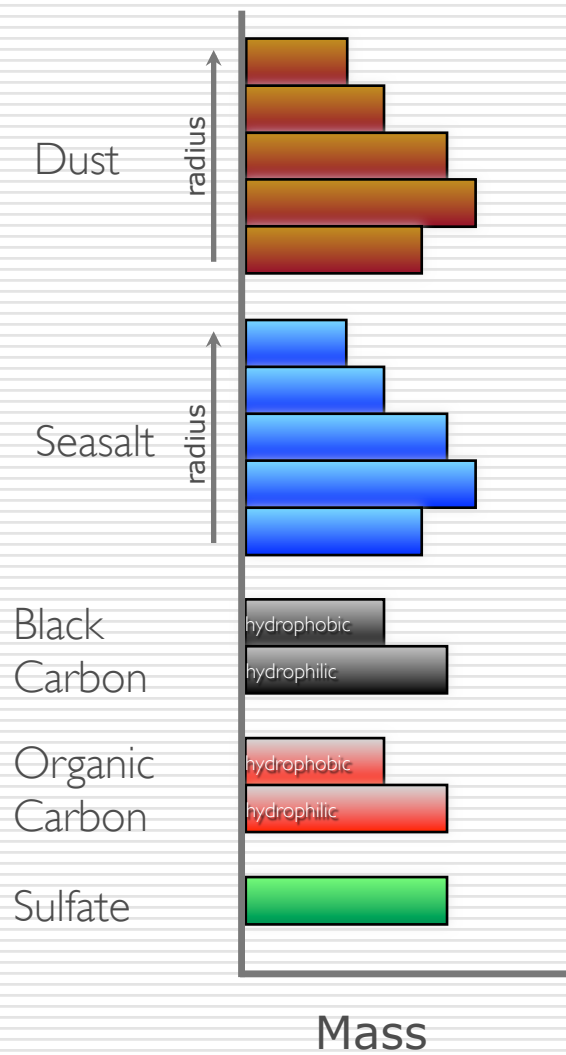
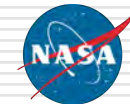
From weather to seasonal to decadal time scales



GEOS-5 Atmospheric Data Assimilation System

| Feature | Description |
|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| Model | GEOS-5 Earth Modeling System, with GOCART coupled to radiation parameterization |
| Fire Emissions | QFED: Daily, NRT, MODIS FRP based |
| Met Data Assim | Full NWP observing system (uses GSI) |
| Aerosol Data Assimilation | Local Displacement Ensembles (LDE) MODIS reflectances (Aqua & Terra) AERONET Calibrated AOD's (Neural Net) Stringent cloud screening |
| Forecasts | 5 day forecasts twice daily: 0Z and 12Z |
| Resolution | 25 km (cubed-sphere), 72 layers, top ~85 km |
| Aerosol Species | Dust, sea-salt, sulfates, organic & black carbon |
| Carbon Species | CO ₂ , CO with several tagged tracers |

GOCART Component

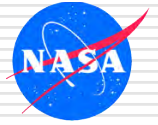


- Goddard Chemistry, Aerosol, Radiation, and Transport Model [Chin et al. 2002]
- Sources and sinks for 5 non-interactive species

| | |
|----------------|------------------------------------------------------------------------------------------|
| dust | wind and topographic source, 5 mass bins |
| sea salt | wind driven source, 5 mass bins |
| black carbon | anthropogenic and wildfire source, mass hydrophobic and hydrophilic |
| organic carbon | anthropogenic, biogenic, and wildfire source, mass hydrophobic and hydrophilic |
| sulfate | anthropogenic and wildfire source of SO ₂ , oxidation to SO ₄ mass |

- Convective and large scale wet removal
- Dry deposition (and sedimentation for dust and sea salt)
- Optics based primarily on OPAC

QFED: Quick Fire Emission Dataset

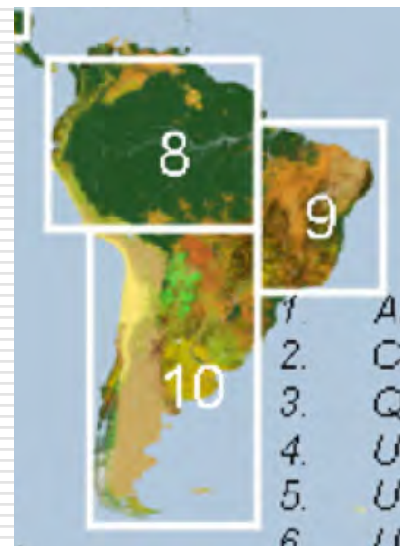
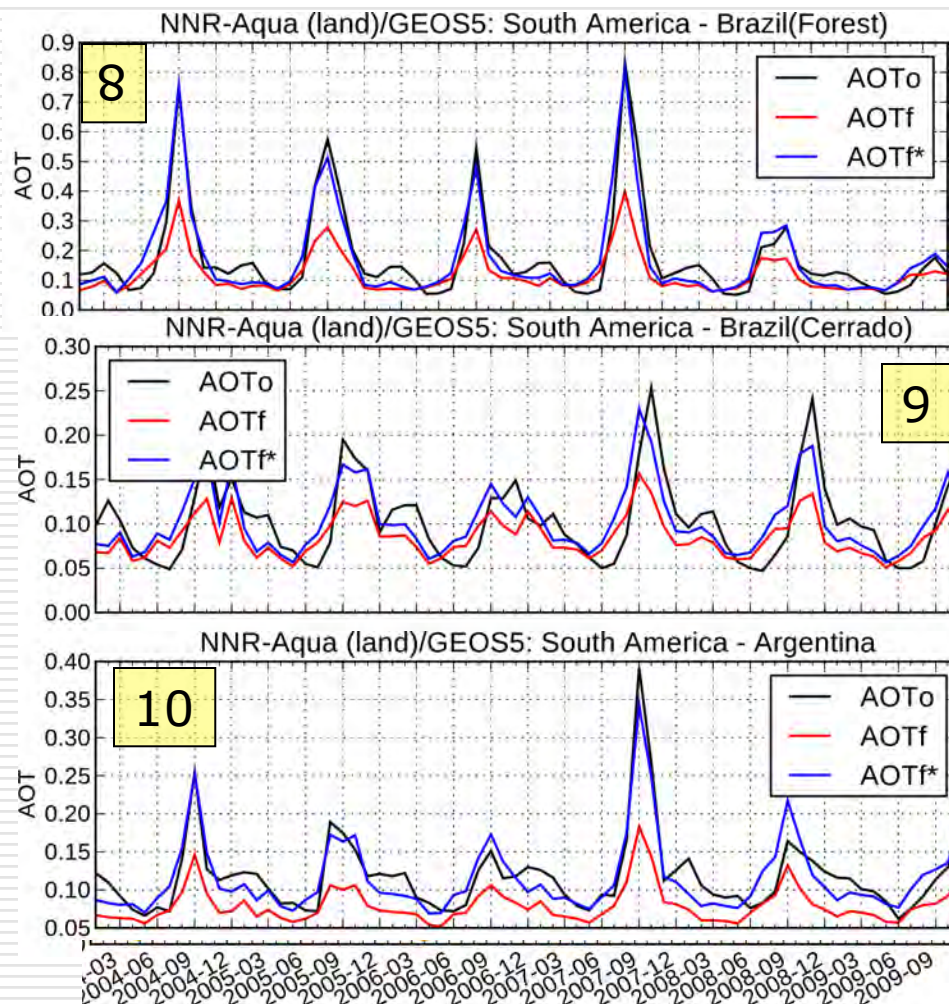


- ❑ Top-down algorithm based on MODIS Fire Radiative Power (AQUA/TERRA)
- ❑ FRP Emission factors tuned by means of inverse calculation based on MODIS AOD data.
- ❑ Daily mean emissions, NRT (thanks to LANCE)
- ❑ Prescribed diurnal cycle



JCSDA: inclusion of geo-stationary information

QFED Calibrated by MODIS AOD



GEOS-5 Aerosol Optical Depth

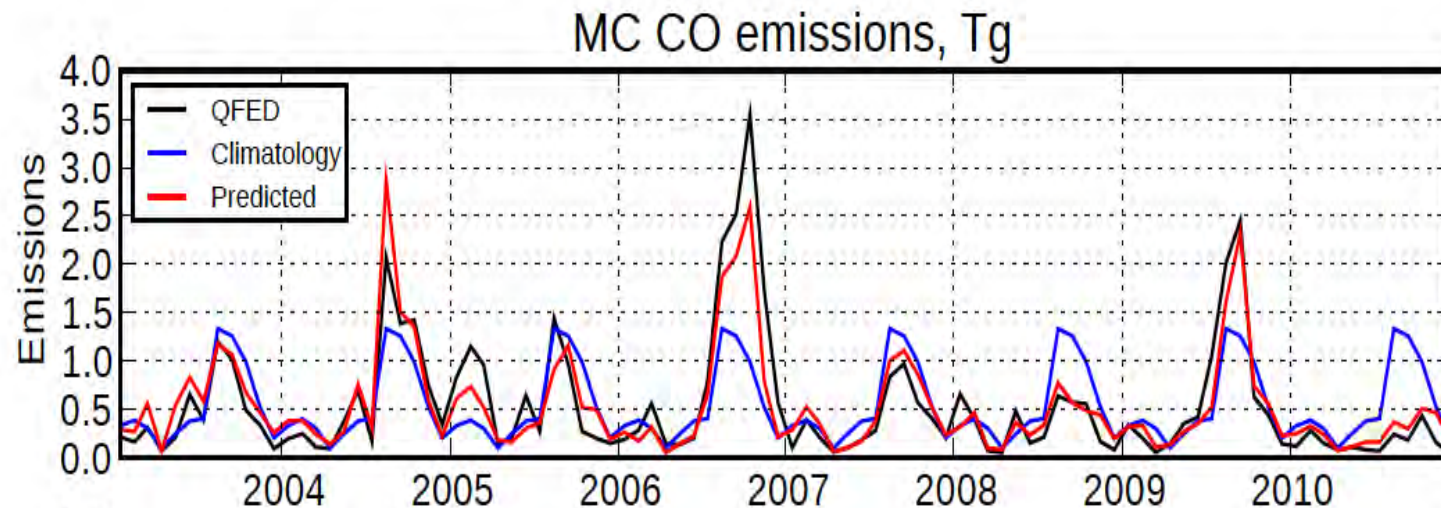
- QFED (GFED Calibrated)
- QFED (MODIS Calibrated)
- MODIS Retrievals

Modeling Interannual Variability of Biomass Burning Emissions

- BB emission anomalies respond directly to precipitation and surface humidity conditions
- The normalized Canadian Fire Weather Index captures the *fammability* conditions as a function of surface meteorology

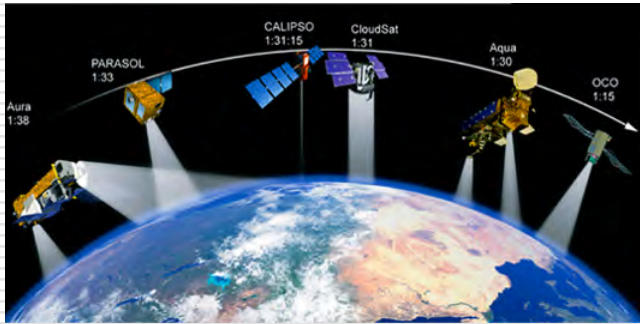
- Parameterization:

$$E = \varepsilon \left(\frac{I}{I_{clm}} \right)^{\alpha_b} E_{clm}$$



Aerosol Data Assimilation

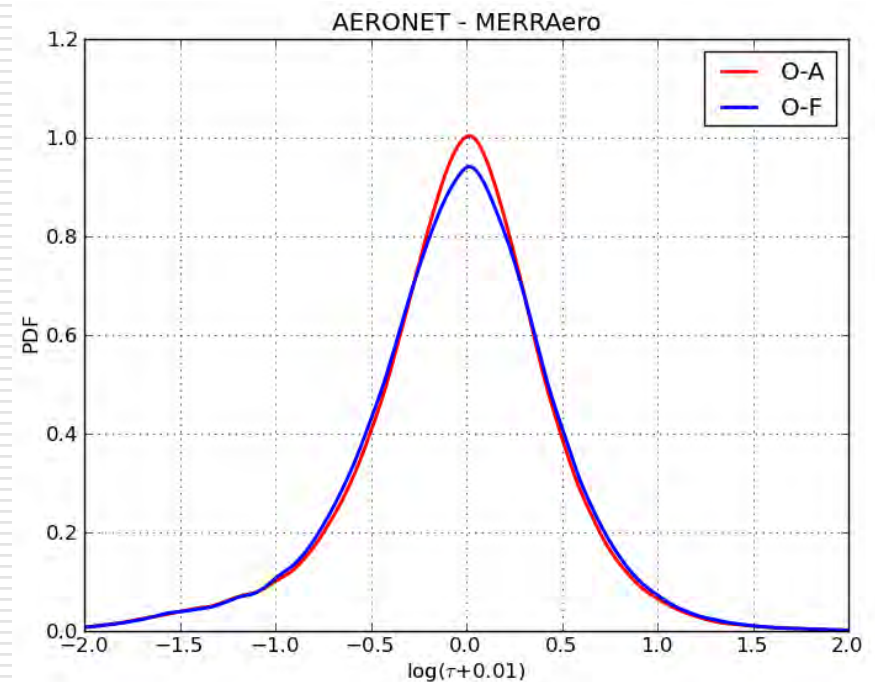
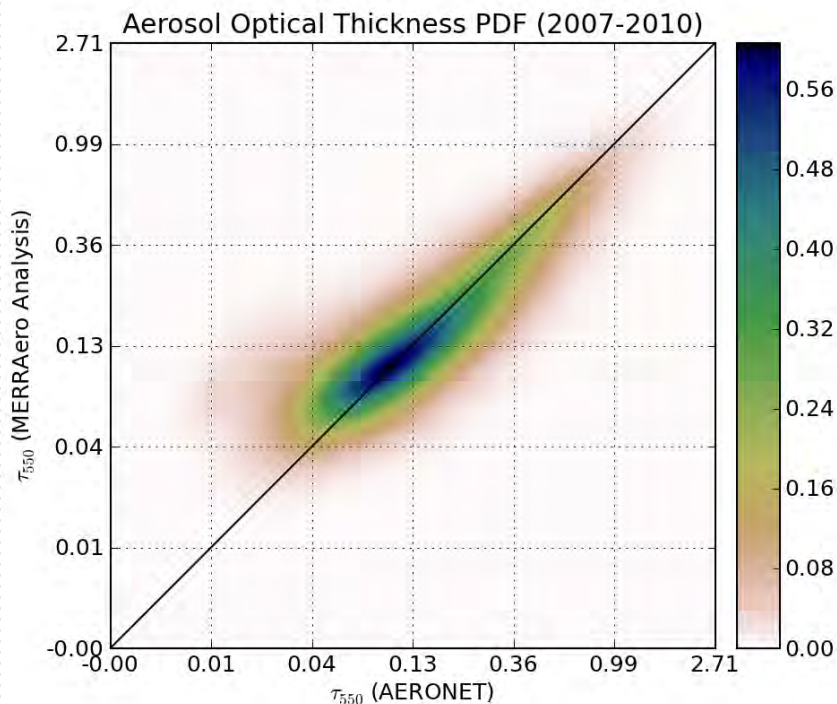
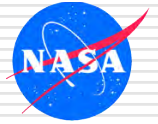
- Focus on NASA EOS instruments, MODIS for now



- Global, high resolution (1/4 deg) **AOD analysis**
- 3D increments by means of Lagrangian Displacement Ensembles (LDE)
- Neural-Net AOD Retrievals

- Simultaneous estimates of background bias (*Dee and da Silva 1998*)
- Adaptive Statistical Quality Control (*Dee et al. 1999*):
 - State dependent (adapts to the error of the day)
 - Background and Buddy checks based on log-transformed AOD **innovation**
- Error covariance models (*Dee and da Silva 1999*):
 - Innovation based
 - Maximum likelihood

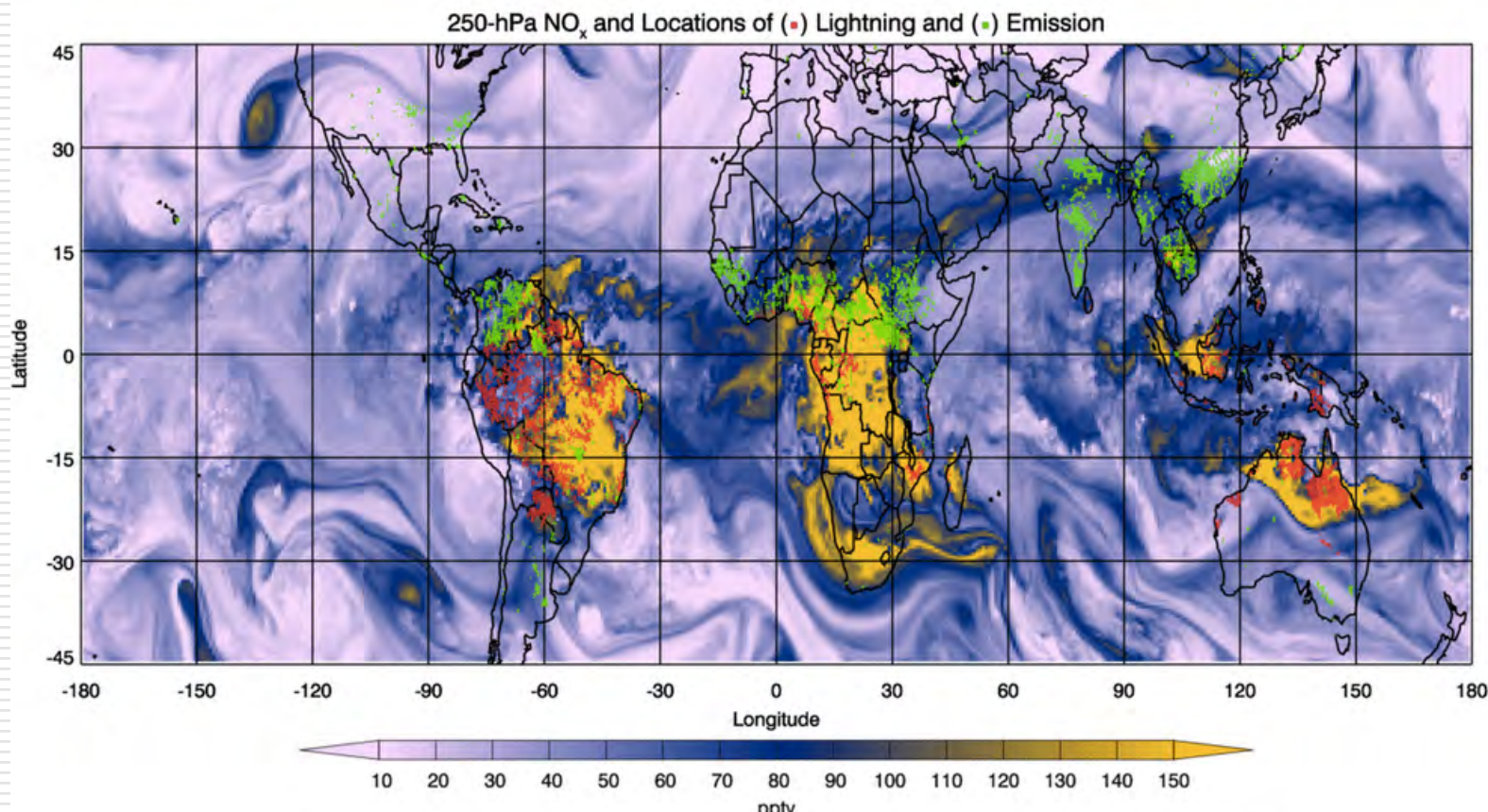
AERONET Validation of Aerosol Assimilation



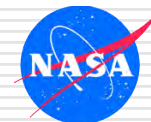
$$\eta = \log(\tau + 0.01)$$

Based on 2007-10 data, aerosol assimilated fields.

A possibility: Experimental Global 25 km GEOS-5/GMI Forecasts



(once a day, 3 or 5 day forecasts)



Mission Specific Customization: SEAC4RS-Asia

SEAC4RS Forecast Support

The **Southeast Asia Composition, Cloud, Climate Coupling Regional Study (SEAC4RS)** will focus specifically on the role of the Asian monsoon circulation and convective redistribution in governing upper atmospheric composition and chemistry in that region. This airborne field campaign will also examine the impact of polluting aerosols on cloud properties and ultimately dynamics.

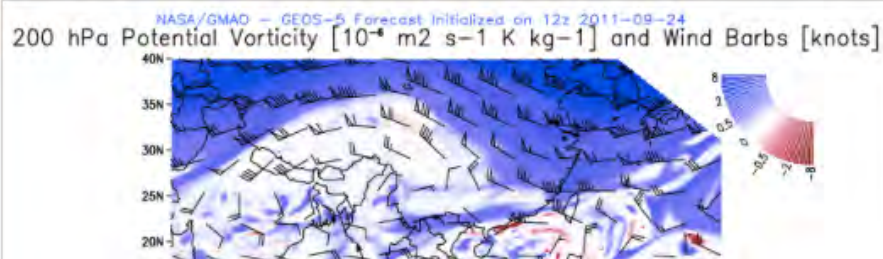
GMAO will provide GEOS-5 forecast support to aid in aircraft mission planning for SEAC4RS. Field measurements will take place in August and September of 2012.



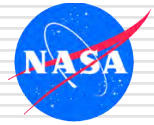
Supporting Forecasts and Data

Wx Maps 2D Chem WX 3D Chem WX Meteograms Envirograms Fires Viewers KML Seasonal Get Data

» Interactive Weather Maps



<http://gmao.gsfc.nasa.gov/projects/SEAC4RS/>



GEOS-5 Support for HS3 ..



Hurricane and Severe Storm Sentinel (HS3) Forecast Support

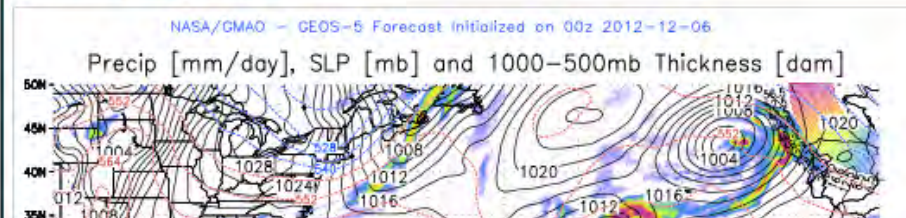
The Hurricane and Severe Storm Sentinel (HS3) is a five-year mission specifically targeted to investigate the processes that underlie hurricane formation and intensity change in the Atlantic Ocean basin. HS3 is motivated by hypotheses related to the relative roles of the large-scale environment and storm-scale internal processes.

Field measurements will take place for one month each during the hurricane seasons of 2012-2014. Test flights will begin in August 2011.

Supporting Forecasts and Data

Wx Maps 2D Chem WX 3D Chem WX Meteograms Aerograms Viewers KML Get Data

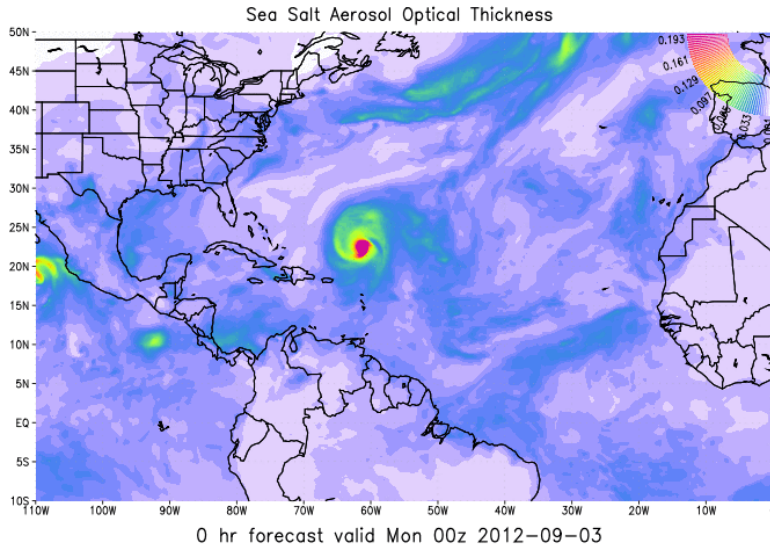
» Interactive Weather Maps



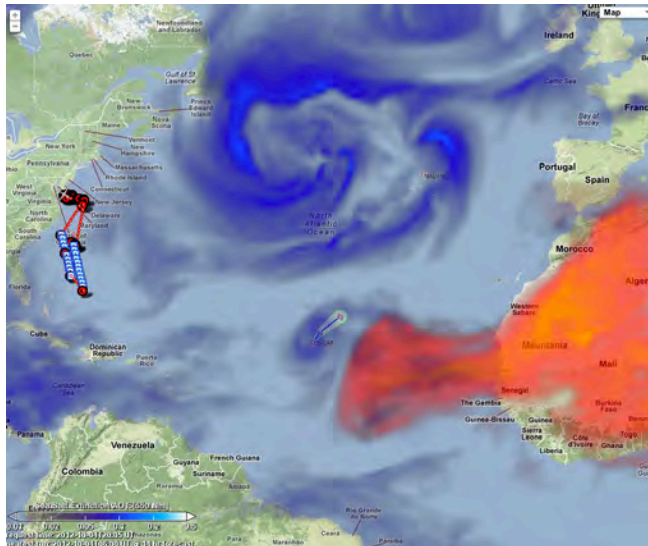
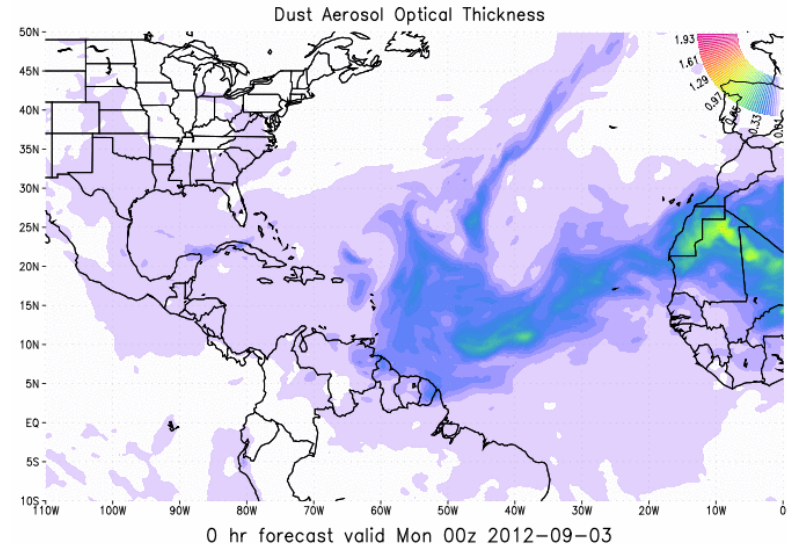
<http://gmao.gsfc.nasa.gov/projects/HS3/>

HS3 Deployment Support

NASA/GMAO – GEOS-5 Forecast Initialized on 00z 2012-09-03



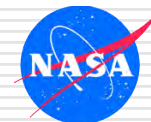
NASA/GMAO – GEOS-5 Forecast Initialized on 00z 2012-09-03



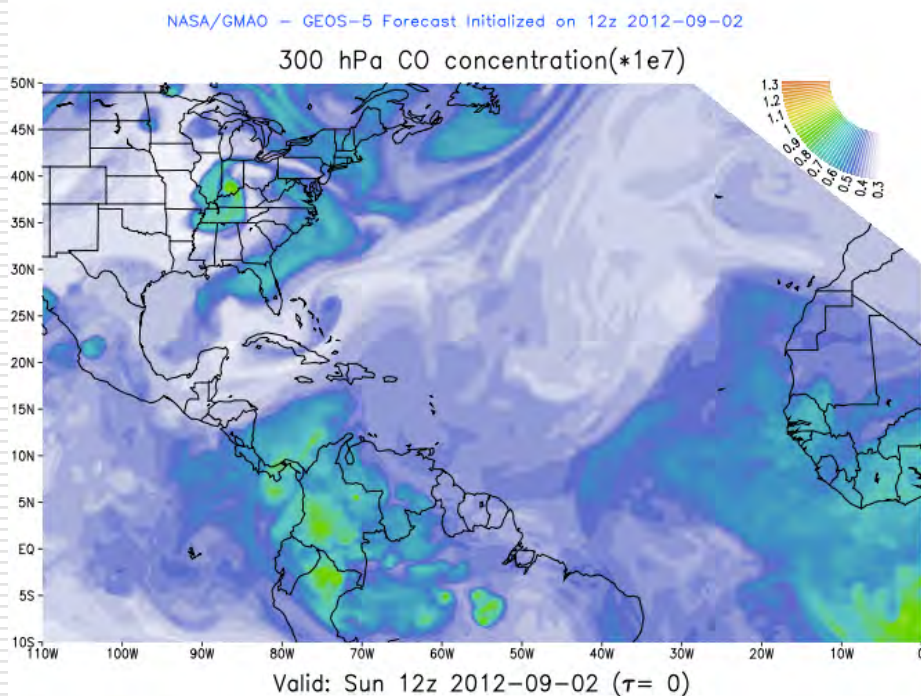
Deployment Activities

4 x day, 5-day meteorological and aerosol forecasts with products made available by web pages, web map service, opendap, etc.

Pete Colarco and Ed Nowottnick were deployed during parts of the campaign to help forecasting and flight planning activities



HS3 Customized Maps



GMAO Experimental Forecast Suite
GEOS-5 HS3 Mission Support

Map Regions
[HS3](#)



GMAO WxMaps

Forecast Initial Time

2012-Sep-02 12z

Forecast Lead Hour

000

Levels

3D CO

3D Aerosols
& Others

50

CO Concentration

Dust Mass

70

CO BB Africa

Black Carbon

100

CO BB Eurasia

Organic Carbon

150

CO BB N. Amer.

SO₂

200

CO BB OTHER

SO₄

300

CO BB S. Amer.

400

CO FF Asia

500

CO FF Europe

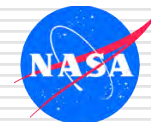
600

CO FF N. Amer.


700

850

Animate



DISCOVER-AQ



See also [DISCOVER-AQ 2011 Campaign support page](#).

DISCOVER-AQ 2013 Campaign GEOS-5 Forecasting Support

DISCOVER-AQ (Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality) is a four-year campaign to improve the use of satellites to monitor air quality for public health and environmental benefit.

This field campaign will provide systematic and concurrent observations of column-integrated, surface, and vertically-resolved distributions of aerosols and trace gases relevant to air quality as they evolve throughout the day. This will be accomplished with a combination of two NASA airborne platforms (sampling in coordination with re-locatable and fixed surface networks. Through these targeted airborne and ground-based observations, DISCOVER-AQ will enable more effective use of current and future satellites to diagnose ground level conditions influencing air quality.

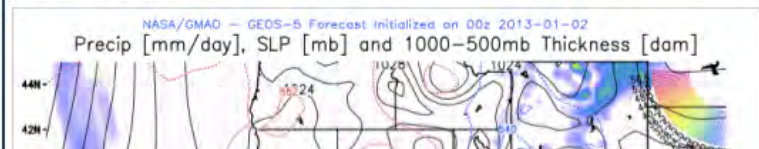
DISCOVER-AQ will deploy for flights over the San Joaquin Valley of California in January 2013. Read more about the [science objectives](#) of DISCOVER-AQ.

» [DISCOVER-AQ Flight Tracker](#)

Supporting Forecasts and Data

Wx Maps 2D Chem WX 3D Chem WX Meteograms Aerograms Viewers Get Data

» Interactive Weather Maps

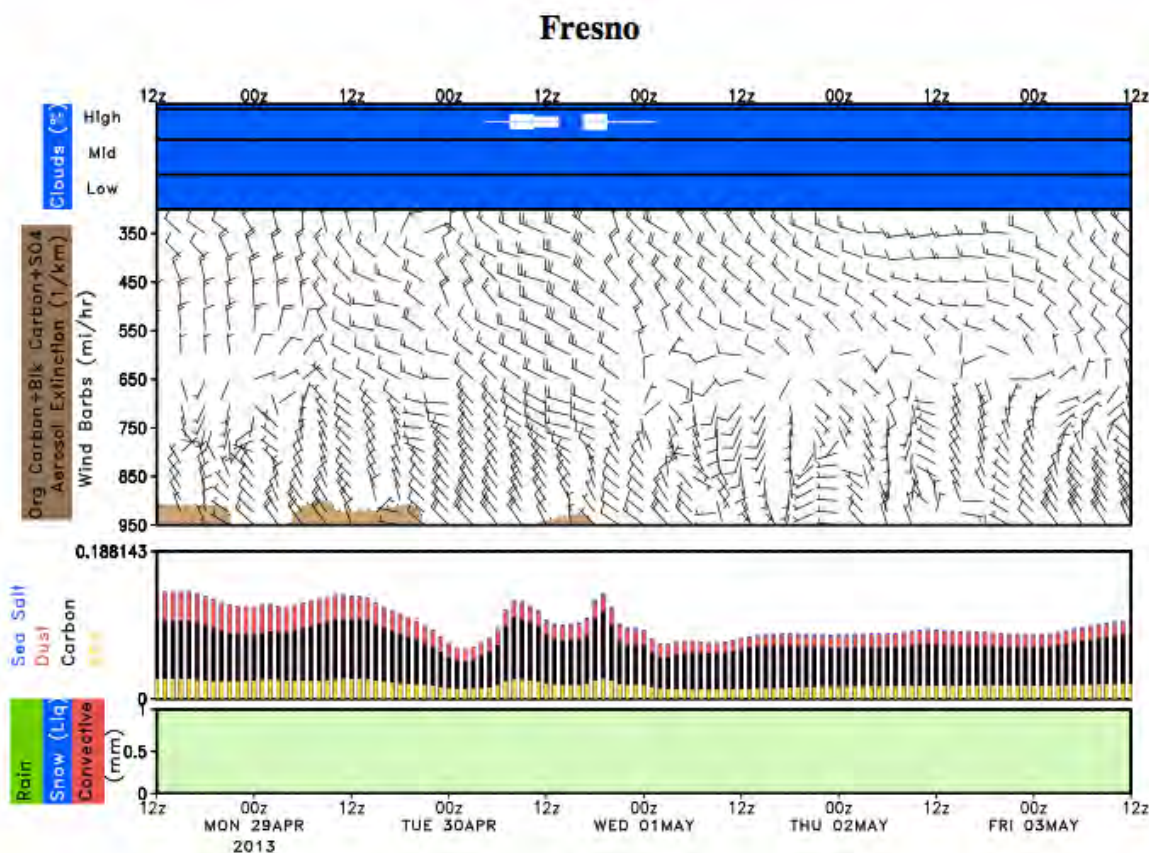


NASA/GMAO — GEOS-5 Forecast initialized on 00z 2013-01-02

Precip [mm/day], SLP [mb] and 1000-500mb Thickness [dam]

<http://gmao.gsfc.nasa.gov/projects/DISCOVER-AQ/>

Aerograms

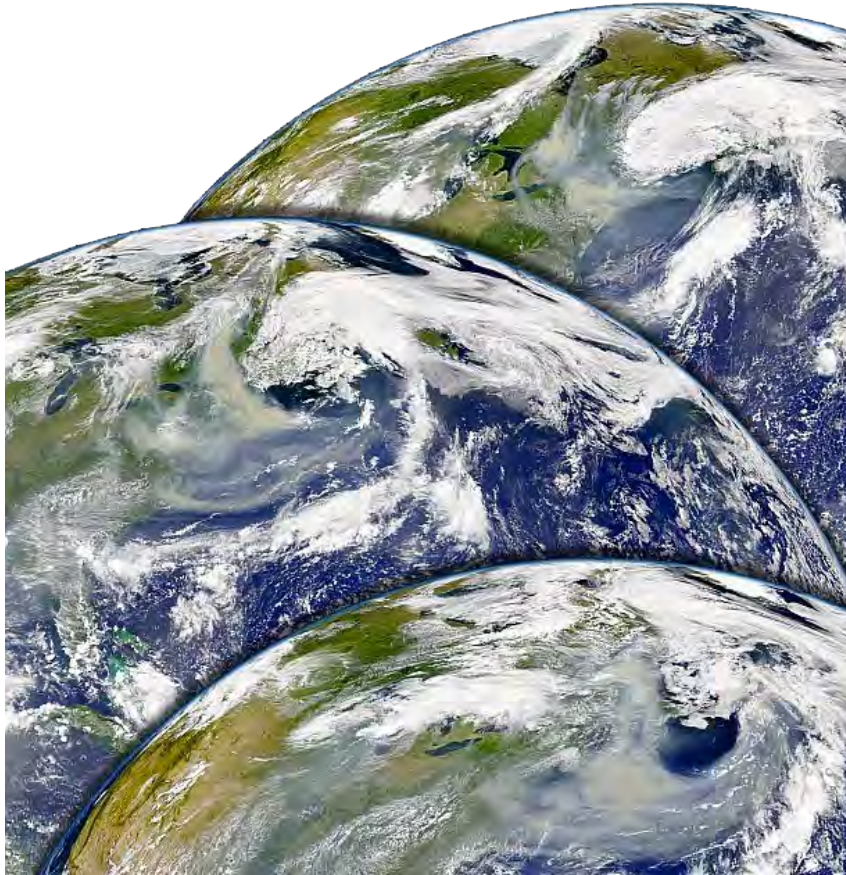


**GEOS-5
Aerograms**

| National | International |
|----------|---------------|
| Fresno | Select |

- [OC Organic Carbon Extinction](#)
- [BC Black Carbon Extinction](#)
- [ALL \(OC + BC + SU\) Extinction](#)
- [SS Sea Salt](#)
- [DU Dust](#)
- [SU Sulfate Extinction](#)
- [CO Concentration](#)

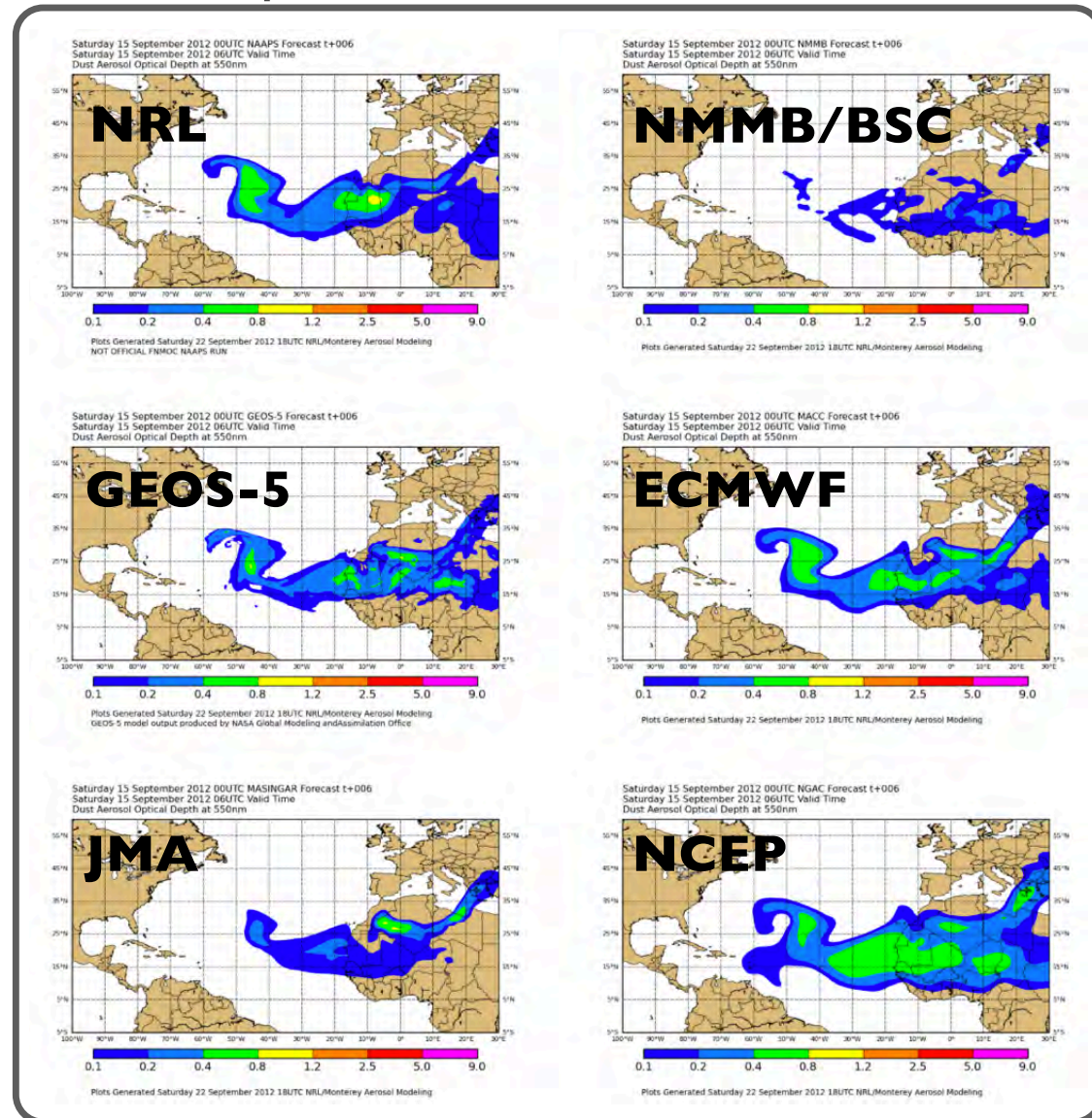
International Cooperative for Aerosol Prediction (ICAP)



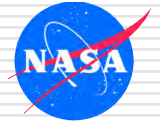
- ICAP is an emerging collaboration of “operational” aerosol forecasters and data providers to coordinate and improve aerosol prediction
 - ICAP goals
 - Communication and collaboration between operational prediction centers
 - Communication and collaboration between model developers and data providers
 - Develop metrics for evaluating skill of model forecasts (similar to NWP community)
 - Develop techniques for aerosol data assimilation
 - Develop techniques for ensemble model forecasting
- Observability, Monterey, CA, April 2010

ICAP Accomplishments

- Participation from all major operational centers: NRL, NCEP, NASA, ECMWF, JMA, UKMO
- Participation from all major data providers: ESA, EUMETSAT, JAXA, NASA, NESDIS
- ICAP workshops
 - Observability, Monterey, CA, April 2010
 - Verification, Oxford, UK, Sept. 2010
 - Ensembles, Boulder, CO, May 2011
 - Sources & Sinks, Frascati, IT, May 2012
- Two workshop write-ups in BAMS
- ICAP Multi-Model Ensemble



ICAP Multi-Model Ensemble Dust Forecast



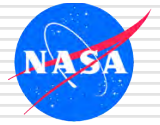
Summary

- SEAC4RS-NA will have a good mix of regional and global models
 - Diversity of emissions
 - Diversity of chemistry/physics
 - Much of the forecasting infrastructure that was developed for SEAC4RS-Asia can be re-purposed for SEAC4RS-NA
 - Adapted for the revised science goals/*score-cards*
 - We should leverage the concurrent DISCOVER-AQ/HS3 forecasting activities.
 - Need to characterize model skill before deployment
-

Extra Slides

Useful GEOS-5 URLs, etc

Sample GEOS-5 Aerosol Data Products



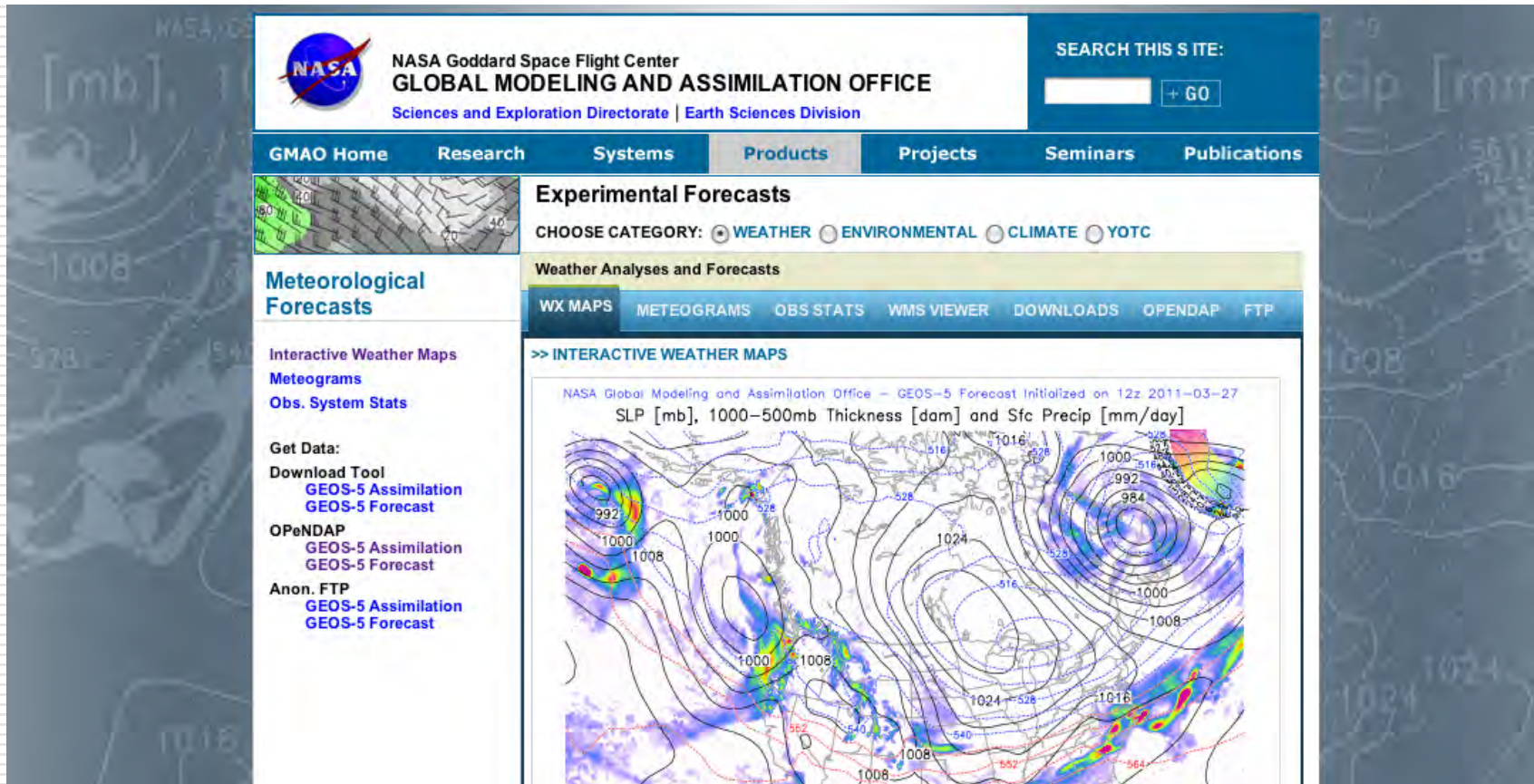
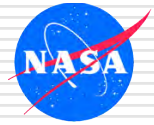
2D Datasets

- ☐ Hourly, 3-hourly
- ☐ Speciated
 - AOT, AAOT, PM2.5, PM10
 - ☐ 12 wavelengths
 - ☐ 340, 380, 440, 470, 500, 550, 670, 865, 1024, 1240, 1640, 2130
 - Surface & column mass
 - Sources & sinks
- ☐ Non-speciated
 - Aerosol radiative forcing
 - UV aerosol Index

3D Datasets

- ☐ 3-hourly
- ☐ Speciated:
 - Aerosol mixing ratio
- ☐ Non-speciated
 - 355nm, 532nm, 1024nm
 - Aerosol Extinction
 - Single Scattering Albedo
 - Asymmetry parameter
 - Backscatter
 - Attenuated Backscatter (TOA & SFC)

GEOS-5 NRT Forecasting - Meteorology



<http://gmao.gsfc.nasa.gov/forecasts>

SLP [mb], 1000–500mb Thickness [dam] and Sfc Precip [mm/day]



GMAO WxMaps

Forecast Initial Time

2011-Mar-27 12z

Forecast Lead Hour

000

Models

GEOS-5

GFS

Variables

300 Speed

500 Vort

700 RH

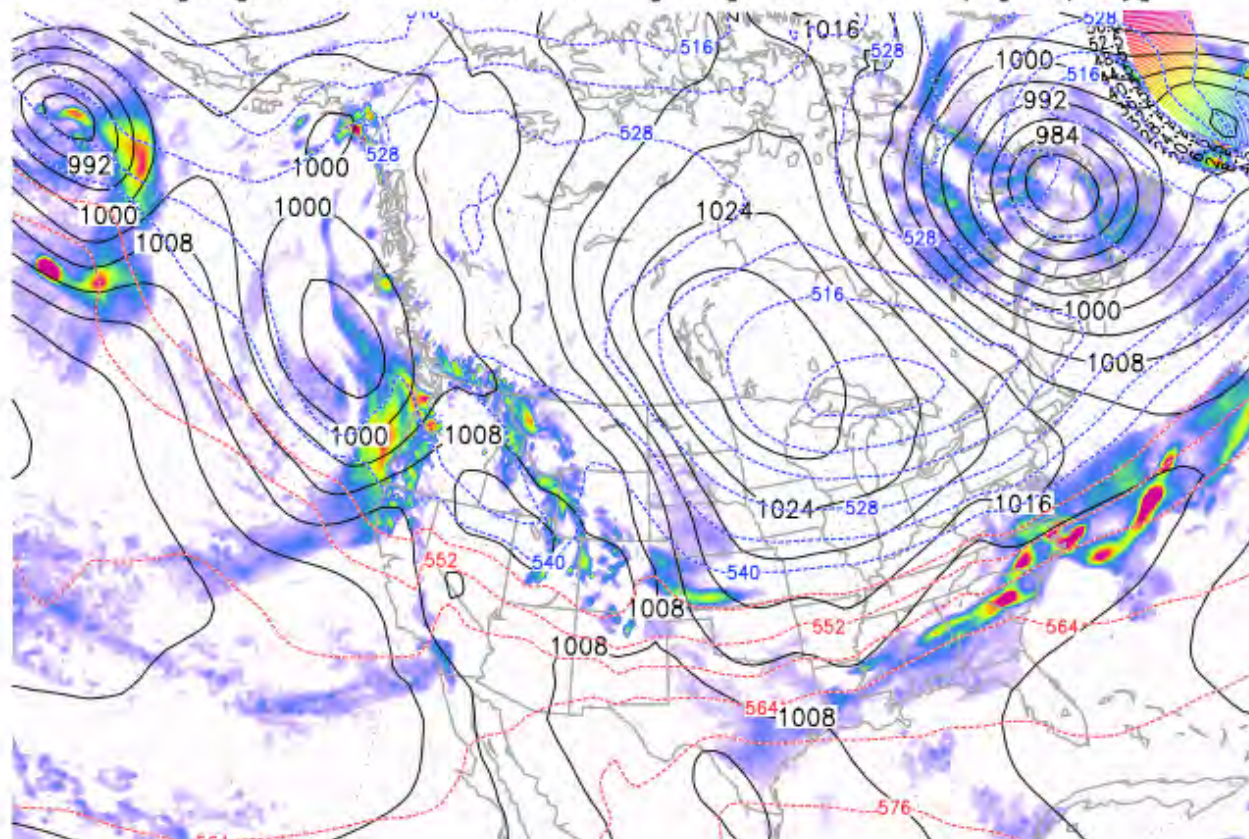
850 Stream

Precip & SLP

Animate

All τ for Precip & SLP

All Products for $\tau=0$



0 hr forecast valid Sun 12z 2011-03-27



GMAO Experimental Forecast Suite

Site Developers: *Arlindo da Silva / Tommy Owens / Joon Yoon / Austin Conaty, GSFC 610.1*

Responsible NASA Official: *Michele Rienecker, GSFC 610.1*

[Privacy Policy and Security Notice](#)

Site Updated: 2009-06-09

Map Regions

[Australia](#)

[Europe](#)

[Pacific](#)

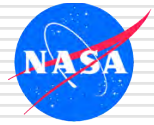
[West Africa](#)

[Tropical Atlantic](#)

[North America](#)

http://portal.nccs.nasa.gov/cgi-yotc/e561_fp_wx.cgi

GEOS-5 Forecasting - Aerosol & Tracers



NASA Goddard Space Flight Center
GLOBAL MODELING AND ASSIMILATION OFFICE
Sciences and Exploration Directorate | Earth Sciences Division

SEARCH THIS SITE: + GO

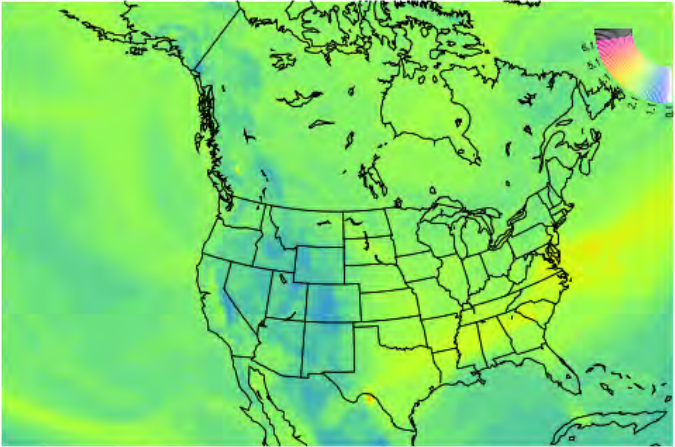
[GMAO Home](#) [Research](#) [Systems](#) [Products](#) [Projects](#) [Seminars](#) [Publications](#)

Experimental Forecasts
CHOOSE CATEGORY: ☐ WEATHER ☒ ENVIRONMENTAL ☐ CLIMATE ☐ YOTC

Environmental Analyses and Forecasts
[CHEMWX](#) [OPeNDAP](#) [FTP](#)

Environmental Forecasts
Interactive ChemWX Maps
OPeNDAP
GEOS-5 Assimilation
GEOS-5 Forecast
EOS Sat. Aerosol Obs.
Anon. FTP
GEOS-5 Assimilation
GEOS-5 Forecast

>> INTERACTIVE CHEMICAL WEATHER MAPS (CHEMWX)
NASA Global Modeling and Assimilation Office - GEOS-5 Forecast Initialized on 12z 2011-03-27
Total CO [10^{18} molecules cm^{-2}]

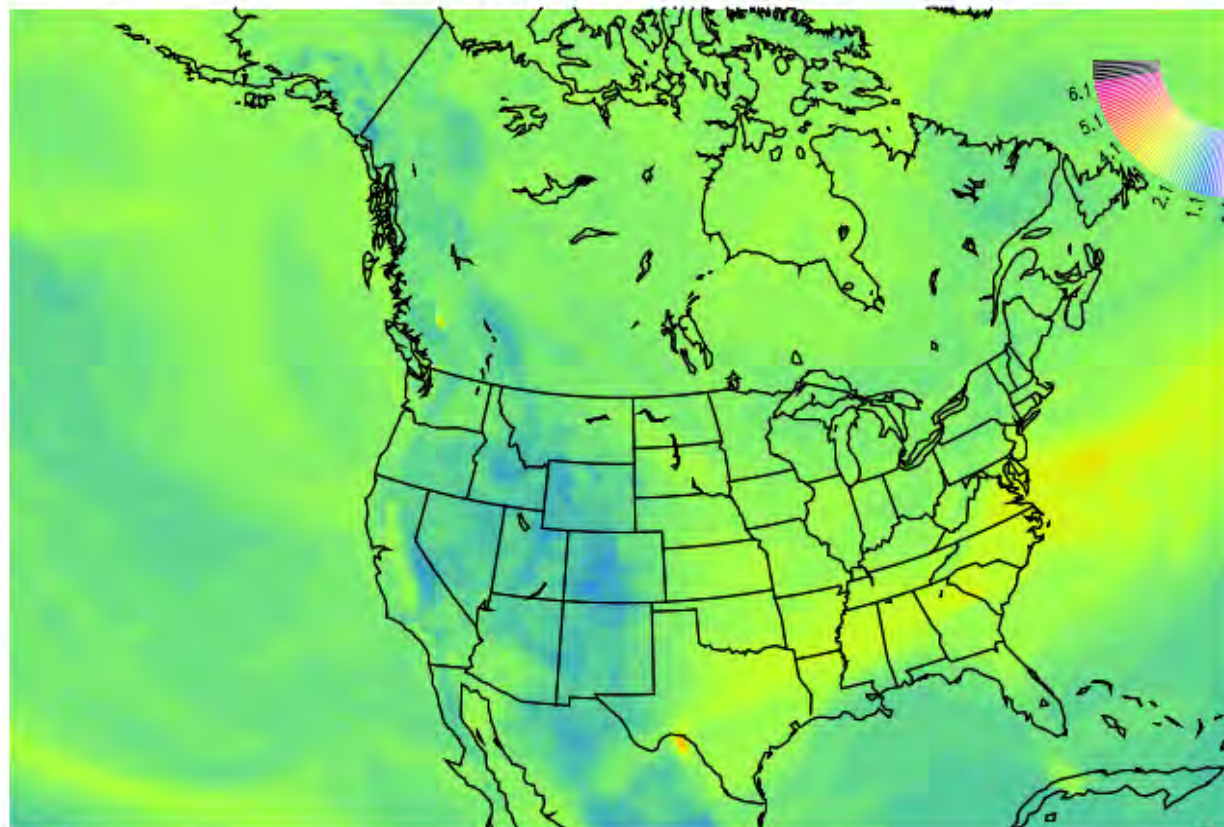


0 hr forecast valid Sun 12z 2011-03-27

click

<http://gmao.gsfc.nasa.gov/forecasts>

Total CO [10^{18} molecules cm^{-2}]



0 hr forecast valid Sun 12z 2011-03-27



GMAO 2D ChemMaps

Forecast Initial Time

2011-Mar-27 12z

Forecast Lead Hour

000

Models

GEOS-5

Variables

CO Column

CO Biomass Burning Eurasia

CO Biomass Burning Africa

CO Biomass Burning South America

CO Biomass Burning Other Regions

CO Fossil Fuel Asia

CO Fossil Fuel Europe

CO Fossil Fuel N. Amer.

Dust AOT

Fine AOT

Total AOT

SO2 Column Mass

SO2 Surface Mass

Total Ozone

Map Regions

Fire Region 1

Fire Region 2

Global

nps

Pacific

North America

Animate



GMAO Experimental Forecast Suite

Site Developers: Arlindo da Silva / Tommy Owens / Joon Yoon / Austin Conaty, GSFC 610.1

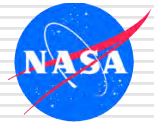
Responsible NASA Official: Michele Rienecker, GSFC 610.1

[Privacy Policy and Security Notice](#)

Site Updated: 2010-06-28

http://portal.nccs.nasa.gov/cgi-yotc/e540_fp_2d_chem.cgi

All τ for CO Column
All Products for τ=0



Getting GEOS-5 Data in NRT

The screenshot shows the NASA Goddard Space Flight Center Global Modeling and Assimilation Office website. The header includes the NASA logo, the office name, and a search bar. The main navigation bar has links for GMAO Home, Research, Systems, Products, Projects, Seminars, and Publications. The 'Experimental Forecasts' section is active, showing a 'CHOOSE CATEGORY' dropdown with options for WEATHER, ENVIRONMENTAL, CLIMATE, and YOTC. Below this, there are tabs for WX MAPS, METEOGRAMS, OBS STATS, WMS VIEWER, DOWNLOADS, OPENDAP, and FTP. The 'INTERACTIVE WEATHER MAPS' section displays a map of the United States with various weather data overlays. On the left sidebar, under 'Meteorological Forecasts', there is a 'Get Data:' section with links for 'Download Tool', 'GEOS-5 Assimilation', and 'GEOS-5 Forecast'. A red arrow points to the 'Download Tool' link.

NASA Goddard Space Flight Center
GLOBAL MODELING AND ASSIMILATION OFFICE
Sciences and Exploration Directorate | Earth Sciences Division

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Experimental Forecasts

CHOOSE CATEGORY: ☒ WEATHER ☐ ENVIRONMENTAL ☐ CLIMATE ☐ YOTC

Weather Analyses and Forecasts

WX MAPS METEOGRAMS OBS STATS WMS VIEWER DOWNLOADS OPENDAP FTP

>> INTERACTIVE WEATHER MAPS

NASA Global Modeling and Assimilation Office - GEOS-5 Forecast Initialized on 12z 2011-03-27
SLP [mb], 1000-500mb Thickness [dam] and Sfc Precip [mm/day]

click

Meteorological Forecasts

Interactive Weather Maps
Meteograms
Obs. System Stats

Get Data:

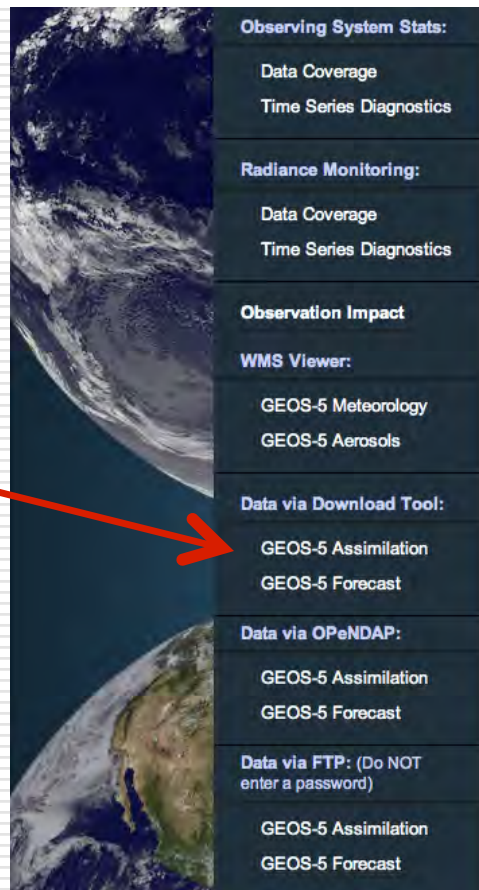
Download Tool
GEOS-5 Assimilation
GEOS-5 Forecast

OPeNDAP
GEOS-5 Assimilation
GEOS-5 Forecast

Anon. FTP
GEOS-5 Assimilation
GEOS-5 Forecast

<http://gmao.gsfc.nasa.gov/forecasts>

Getting GEOS-5 Data in NRT



Observing System Stats:

- Data Coverage
- Time Series Diagnostics

Radiance Monitoring:

- Data Coverage
- Time Series Diagnostics

Observation Impact

WMS Viewer:

- GEOS-5 Meteorology
- GEOS-5 Aerosols

Data via Download Tool:

- GEOS-5 Assimilation
- GEOS-5 Forecast

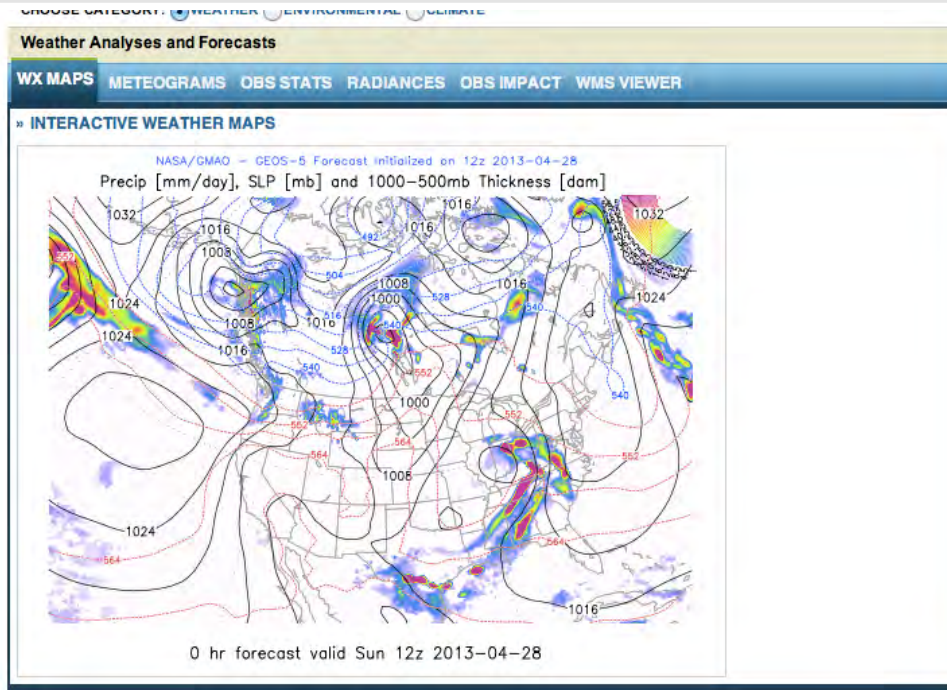
Data via OPeNDAP:

- GEOS-5 Assimilation
- GEOS-5 Forecast

Data via FTP: (Do NOT enter a password)

- GEOS-5 Assimilation
- GEOS-5 Forecast

click



<http://gmao.gsfc.nasa.gov/forecasts>

[GEOS-5](#) - [candidate](#) [fp](#) - [fcast](#) - [inst3](#) [3d](#) [asm](#) [Cp.latest](#)

3d,3-Hourly,Instantaneous,Pressure-Level,Forecast Fields (wind,temperature)

Variable Selection

- ☐ All
- ☐ sea_level_pressure
- ☐ ozone_mass_mixing_ratio
- ☐ specific_humidity
- ☐ surface_geopotential_height
- ☐ erfels_potential_vorticity
- ☐ relative_humidity_after_moist
- ☐ eastward_wind
- ☐ edge_heights
- ☐ surface_pressure
- ☐ vertical_pressure_velocity
- ☐ mass_fraction_of_cloud_liquid_water
- ☐ northward_wind
- ☐ air_temperature
- ☐ mass_fraction_of_cloud_ice_water

Date and Time Range

Begin 2011 Mar 27 00:00 Z

End 2011 Mar 27 00:00 Z

Time Steps 1

Download NetCDF-3, NetCDF-4, HDF-4, HDF-5, GRIB-1 or Binary

Vertical Level Selection

Begin 1000 **End** 1

List Levels:

Geographic Selection



0.00000, 0.00000

- ☐ Pan
- ☒ Draw Box

North: 90
West: -180 East: 180
South: -90

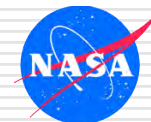
Update

Regridding / Orbital Masking

Choose none **Method** linear

Format

coards



GEOS-5 WMS Server

Go Date and Time

Date: 2011 - 03 - 27 Time: 00 Forecast: 0

NOTE: Actual time of each image is shown beside legend

Go Map Size

Magnify: 100%

Width: 720

Height: 360

Go Lat/Lon Bounding Box (degrees)

Top: 90

Left: -180

Right: 180

Bottom: -90

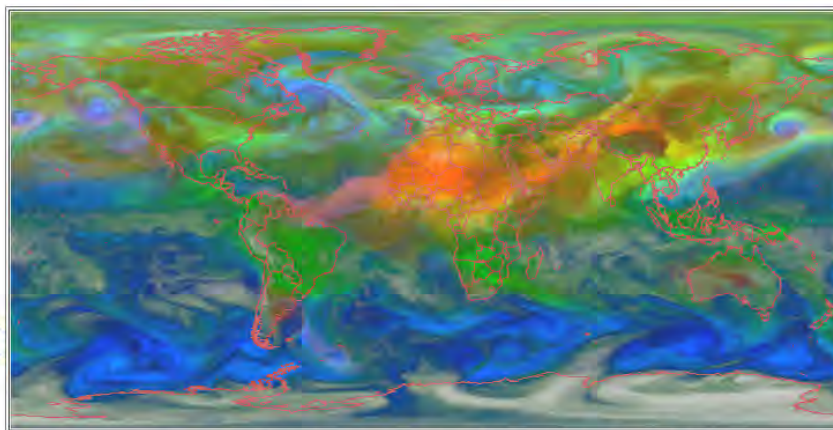
Go Transparency

Transparent: ☒ Yes ☐ No

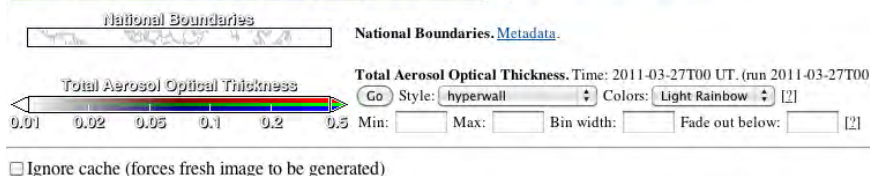
Background: ☒ Black ☐ White NOTE: Some layers are fully opaque

Go Map Layers

- ☒ National Boundaries
- ☒ Total Aerosol Optical Thickness
- ☐ USA State Boundaries 1:20M scale
- ☐ USA State boundaries (internal)
- ☐ Lat/Lon Grid
- ☐ Black Carbon Extinction AOT [550 Nm]
- ☐ CO Column Burden ENSEMBLE
- ☐ CO Column Burden (Boreal Biomass Burning)
- ☐ CO Column Burden (European Anthropogenic)
- ☐ CO Column Burden (Non-Boreal Biomass Burning)
- ☐ CO Column Burden (North American Anthropogenic)
- ☐ CO Column Burden (Northern Asia Anthropogenic)
- ☐ CO Column Burden (Southern Asia Anthropogenic)
- ☐ CO2 Column Load Bin 001
- ☐ Dust Extinction AOT [550 Nm]
- ☐ Organic Carbon Extinction AOT [550 Nm] ENSEMBLE
- ☐ Organic Carbon Extinction AOT [550 Nm] (Boreal Biomass Burning)
- ☐ Organic Carbon Extinction AOT [550 Nm] (Non-Boreal Biomass Burning)
- ☐ SO4 Extinction AOT [550 Nm]
- ☐ Sea Level Pressure
- ☐ Sea Salt Extinction AOT [550 Nm]
- ☐ Total Column Ozone
- ☐ Aqua MODIS 1km True-Color Imagery
- ☐ Terra MODIS 1km True-Color Imagery
- ☐ GOES-12 Full-Disk Long-Wave Infrared Imagery



Click on map to: Zoom ☒ In ☐ Out by 2, or ☐ Recenter [Google Earth KML file \[2\]](#)



WMS Server:

<http://wms.gsfc.nasa.gov/cgi-bin/wms.cgi>

Download NetCDF, GeoTIFF, KML

WMS Viewer: http://http://www.map.nasa.gov/cgi-bin/viewer.cgi?project=geos5-inst2d_hwl_x